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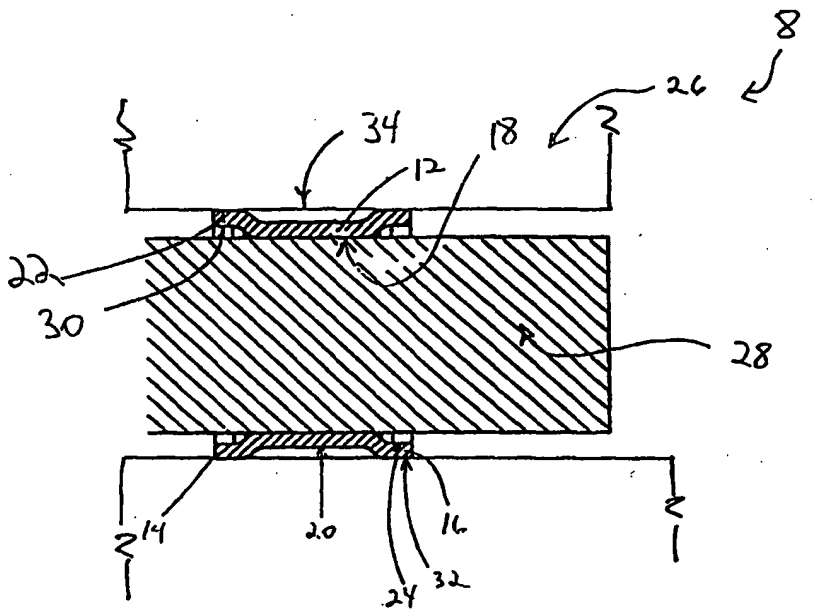
(54) Title: A PLANE BEARING ASSEMBLY



(57) Abstract

A plane bearing assembly includes a bearing defining a longitudinal axis and having an intermediate portion (12) bounded on opposed longitudinal ends by first and second end portions (14, 16). The intermediate portion has an inner working surface (11) and an outer relief surface (20). The first and second end portions have an outer surface (22, 24) which extends radially outward from the outer relief surface of the intermediate portion such that the intermediate portion can be relieved relative to the first and second end portions without substantial deformation of the inner working surface.

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A PLANE BEARING ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This disclosure relates to a plane bearing assembly. In particular a bearing that provides a minimal amount of deformation to its inner working surface.

2. Description of Related Art

Plane bearings define a lubricated surface to engage a translating or rotating shaft. Plane bearings are commonly used for such applications as automotive door-lift mechanisms, belt tensioners, seat height and position adjustment mechanisms, etc. This type of bearing is used to support rotating or reciprocating members or combinations of both motions. The object is to provide a bearing that incorporates the low friction, wear resistance, and lubricating properties into the bore of the bearing to allow efficient motion therein. Polymer type bearings are often used for their desired properties (see Thomson U.S. Patent No. 2,675,283).

Since polymeric material is inherently flexible, press-fitting of a strictly cylindrical geometry is difficult and results in a distortion of the working bore, tending to close the bore in on the shaft. This is disadvantageous because a working fit with an adequate clearance is necessary in order for a shaft to rotate or translate efficiently.

Attempts have been made in the past to retain the bearing within the housing bore. Many techniques have been implemented at the cost of additional assembly steps or tooling costs. For example, Rosen, U.S. Patent No. 4,913,562 teaches a center flange arrangement wherein the flange engages the housing by an internal groove. The internal groove must be added to the housing often requiring

added expense due to machining costs. Further, the flange must be designed to properly fit within the bore and the groove engaging it. Further external flanges make it difficult to insert the bearing into the housing. Rosen U.S. Patent No. 4,913,562 addresses this difficulty by creating a diagonal slit longitudinally down the bearing. The bearing can now be flexed helically to install it into the housing bore. The slit must be incorporated into the molding process of the bearing creating additional tooling expense.

End flanges have been used to eliminate the need for creating an internal groove in the housing bore. Flem, U.S. Patent 5,145,265 teaches of such a technique, but also includes a longitudinal diagonal slit down the side wall of the bearing for ease of installation.

It is advantageous to have a bearing that can be molded using a simple technique, that is without slits or flanges. Further, it is desirable to provide a bearing that is easy to install, eliminating the need to create helical slits or cuts within the bearing. Additionally, a bearing that supports a shaft continuously without an interruption of a diagonal slit is preferred.

SUMMARY OF THE INVENTION

A plane bearing assembly includes a bearing defining a longitudinal axis and having an intermediate portion bounded on opposed longitudinal ends by first and second end portions. The intermediate portion has an inner working surface and an outer relief surface. The first and second end portions have an outer surface which extends radially outward from the outer relief surface of the intermediate portion such that the intermediate portion can be relieved relative to the first and second end portions without substantial deformation of the inner working surface.

BRIEF DESCRIPTION OF DRAWINGS

The invention will be described in detail in the following description of preferred embodiments with reference to the following figures wherein:

FIG. 1 is an isometric view of a preferred embodiment of an improved bearing assembly;

FIG. 2 is a cross-sectional view of a preferred embodiment of an improved bearing assembly;

FIG. 3 shows a cross section of the bearing assembly installed within a housing bore with a shaft passing through the bearing; and

FIG. 4 shows a magnified cross-sectional view of end portion 16.

FIG. 5 shows a cross-sectional view of housing structure 26 wherein interior surface 34 includes different diameters.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

An improved bearing assembly is cylindrically shaped with raised end portions. The raised end portions create an interference fit with the interior of a housing bore in which it is installed. The improved bearing provides a low friction, low wear surface for contacting a shaft within its internal bore. The internal bore provides a working surface that is continuous for consistent contact with a shaft during operation. Further the press-fit of the bearing minimizes close-in over the working interior bore of the bearing, that is the bearing's inside diameter does not impinge significantly on the clearance between the bearing and the shaft.

Referring to the figures, FIG. 1 is an isometric view of a preferred embodiment of a plane bearing 10.

FIG. 2 is a cross-sectional view of a preferred embodiment of bearing 10. The bearing assembly defines a bore 11. Bearing 10 is generally cylindrical in shape with two end portions 14 and 16. The bearing has an intermediate portion 12 which has an inner working surface 18 which supports a shaft 28 during operation. In a preferred embodiment, raised end portions 14 and 16 maintain a constant wall thickness which is approximately equal to the wall thickness of the intermediate portion 12. However, other thicknesses for end portions 14 and 16 are contemplated. Outer surfaces 22 and 24 of the end portions 14 and 16 are extended radially outward beyond the intermediate portion's outer relief surface 20. Also, a preferred embodiment includes inner surfaces 30 and 32 of end portions 14 and 16 which define a larger diameter than inner working surface 18 of intermediate portion 12 of bearing 10. Because end portions 14 and 16 are raised, outer relief surface 20 is defined in intermediate portion 12 of bearing 10. Slots 23 may also be formed in end portions 14 and 16. These slots 23 facilitate accommodation of bearing 10 in a carriage.

FIG. 3 shows a cross section of a bearing assembly 8 installed within a housing bore with a shaft passing through bearing 10. A housing structure 26 defines a bore having an interior surface 34. Bearing 10 is press-fit into housing structure 26. Outer surfaces 22 and 24 of end portions 14 and 16 contact interior surface 34 of housing structure 26. The diameter of housing structure 26 is less than the diameter defined by outer surfaces 22 and 24 of end portions 14 and 16. Therefore, an interference fit is created. Bearing 10 may be made of a compliant material which can deform at end portions 14 and 16 (See FIG. 4). Preferably, outer relief surface 20 of intermediate portion 12 does not contact interior surface 34 of housing structure 26. Inner working surface 18 is in contact with shaft 28, however enough clearance is allocated for shaft 28 to translate, rotate or translate and rotate simultaneously.

Appropriate clearances between interior surface 34 and outer surfaces 22 and 24, as well as, between shaft 28 and inner working surface 18 are important to the proper operation of the configuration. Preferred interferences between interior surface 34 and outer surfaces 22 and 24 of end portions 14 and 16 are in the range of .001 to .005 inches for housing structure bore diameters of approximately .25 inches to 2.50 inches. Typical clearances between the diameter of shaft 28 and the diameter of inner working surface 12 are nominally .004 inches for shaft diameters between .25 inches to about 2.50 inches. Too much clearance is detrimental to the efficient operation of the bearing. Chatter or noise can result as well as rough motion of the shaft. Clearance that is too small can cause shaft interference which is also non-beneficial to bearing operation.

A preferred embodiment of this invention addresses these concerns. The diameter of outer surfaces 22 and 24 of end portions 14 and 16 is larger than interior surface 34 of housing structure 26. There exists a condition of interference between the two which is maintained within the preferable range of .001 to .005 inches for approximate housing bore diameters between .25 inches to about 2.5 inches. This range may increase as required by increasing shaft diameter. Outer relief surface 20 is smaller than the diameter of the housing bore. Therefore, there is no interference in the intermediate portion 12 of bearing 10, since shaft 28 is supported by the inner working surface 18 in intermediate portion 12. Preferably any reduction in diameter of inner working surface 12 is maintained below .003 inches to remain within the nominal clearance range of .001 to .004 inches for shafts less than .25 inches to about 2.5 inches.

FIG. 4 shows a magnified cross-sectional view of end portion 16. End portion 16 is shown in an undeformed structure (solid lines) and a deformed structure (dashed lines). The solid lines represent end portion 16 prior to press-fitting bearing 10 into bore 26. When bearing 10 is pressed into housing structure

26 both inner surface 32 and outer surfaces 24 deform radially inward, filling at least part of the available space between inner surface 32 and shaft 28. Since only outer surface 24 of end portion 16 is in contact with housing bore 26, intermediate portion 12 is not loaded externally, and therefore does not substantially deform radially inward closing in the diameter of inner working surface 12. Therefore, a press-fit bearing arrangement is realized maintaining an appropriate clearance between shaft 28 and the inner working surface 12.

Preferred material characteristics for bearing 10 include low-friction, low-wear, high strength and good performance at elevated temperatures. Materials with some flexibility are desired to undergo the deformation of press fitting without excessive stress. It is also desirable that the materials are resilient enough to hold their shape so that cold flow or creep does not present problems for the bearing. In preferred embodiments polymeric materials may be used in particular, polyamide (PA) including but not limited to nylon 6/6, polyphenylene sulfide (PPS) and polyphthalamide (PPA) thermoplastics.

Alternate embodiments of bearing 10 include end portions 14 and 16 having different diameters. FIG. 5 shows a cross-sectional view of housing structure 26 wherein interior surface 34 includes different diameters. It is also contemplated that end portions 14 and 16 can have different longitudinal lengths to accommodate varying housing structure sizes. It is further contemplated that intermediate portion 12 can have varied longitudinal lengths and diameters to accommodate varying housing structures.

Having described preferred embodiments of an improved bearing (which are intended to be illustrative and not limiting), it is noted that the modifications and variations could be made by those skilled in the art in light of the above teachings. It is therefore to be understood that changes may be made in

the particular embodiments of the invention disclosed which are within the scope and spirit of the invention defined by the appended claims.

WHAT IS CLAIMED IS:

1. A plane bearing assembly comprising:

a bearing defining a longitudinal axis and having an intermediate portion bounded on opposed longitudinal ends by first and second end portions, the intermediate portion having an inner working surface and an outer relief surface, the first and second end portions having an outer surface which extends radially outward from the outer relief surface of the intermediate portion such that the intermediate portion can be relieved relative to the first and second end portions without substantial deformation of the inner working surface.

2. A plane bearing assembly as recited in claim 1 further comprising a housing structure defining a bore for receiving the bearing therein.

3. A plane bearing assembly as recited in claim 2 wherein the first and second end portions having an interference fit with the housing structure.

4. A plane bearing assembly as recited in claim 3 wherein the interference fit is between .001 and .005 inches.

5. A plane bearing assembly as recited in claim 2, wherein the inner working surface deforms less than or equal to .003 inches.

6. A plane bearing assembly as recited in claim 1 wherein the bearing consists of a polymeric material.

7. A plane bearing assembly as recited in claim 6 wherein the bearing consists of polyamide.

8. A plane bearing assembly comprising:

a substantially cylindrical bearing defining a longitudinal axis and having an intermediate portion bounded on opposed longitudinal ends by first and second end portions, the intermediate portion having an inner working surface and an outer relief surface, the first and second end portions having an outer surface which extends radially outward from the outer relief surface of the intermediate portion such that the intermediate portion can be relieved relative to the first and second end portions without substantial deformation of the inner working surface; and

the first and second end portions having an inner surface extending radially outward from the inner working surface allowing for radially inward deformation of the first and second end portions.

9. A plane bearing assembly as recited in claim 8 further comprising a housing structure defining a bore for receiving the bearing therein.

10. A plane bearing assembly as recited in claim 9 wherein the first and second end portions having an interference fit with the housing structure.

11. A plane bearing assembly as recited in claim 10 wherein the interference fit is between .001 and .005 inches.

12. A plane bearing assembly as recited in claim 8, wherein the inner working surface deforms less than or equal to .003 inches.

13. A plane bearing assembly as recited in claim 8 wherein the bearing consists of a polymeric material.

14. A plane bearing assembly as recited in claim 13 wherein the bearing consists of polyamide.

15. A plane bearing assembly comprising:

a polymeric substantially cylindrical bearing defining a longitudinal axis and having an intermediate portion bounded on opposed longitudinal ends by first and second end portions, the intermediate portion having an inner working surface and an outer relief surface, the first and second end portions having an outer surface which extends radially outward from the outer relief surface of the intermediate portion such that the intermediate portion can be relieved relative to the first and second end portions without substantial deformation of the inner working surface;

a housing structure defining a bore for receiving the bearing therein; and

the first and second end portions having an inner surface extending radially outward from the inner working surface allowing for radially inward deformation of the first and second end portions wherein the first and second end portions having an interference fit with the housing structure.

16. A plane bearing assembly as recited in claim 15 wherein the interference fit is between .001 and .005 inches.

17. A plane bearing assembly as recited in claim 15, wherein the inner working surface deforms less than or equal to .003 inches.

18. A plane bearing assembly as recited in claim 15 wherein the bearing consists of polyamide.

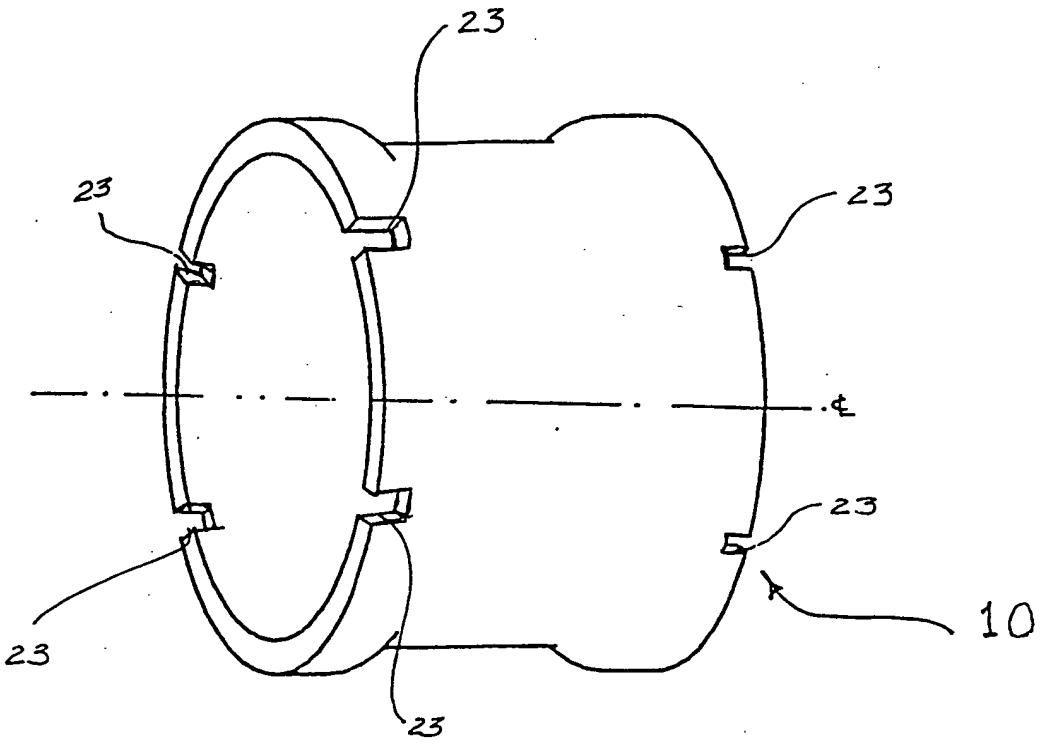

FIGURE 1

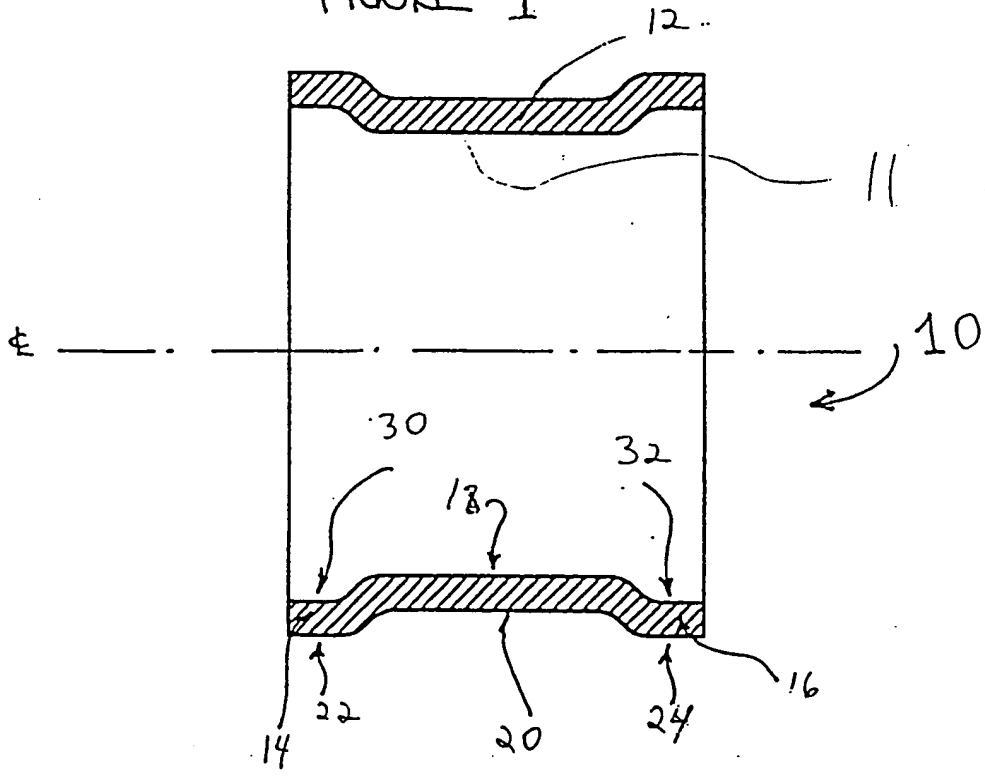

Figure 2

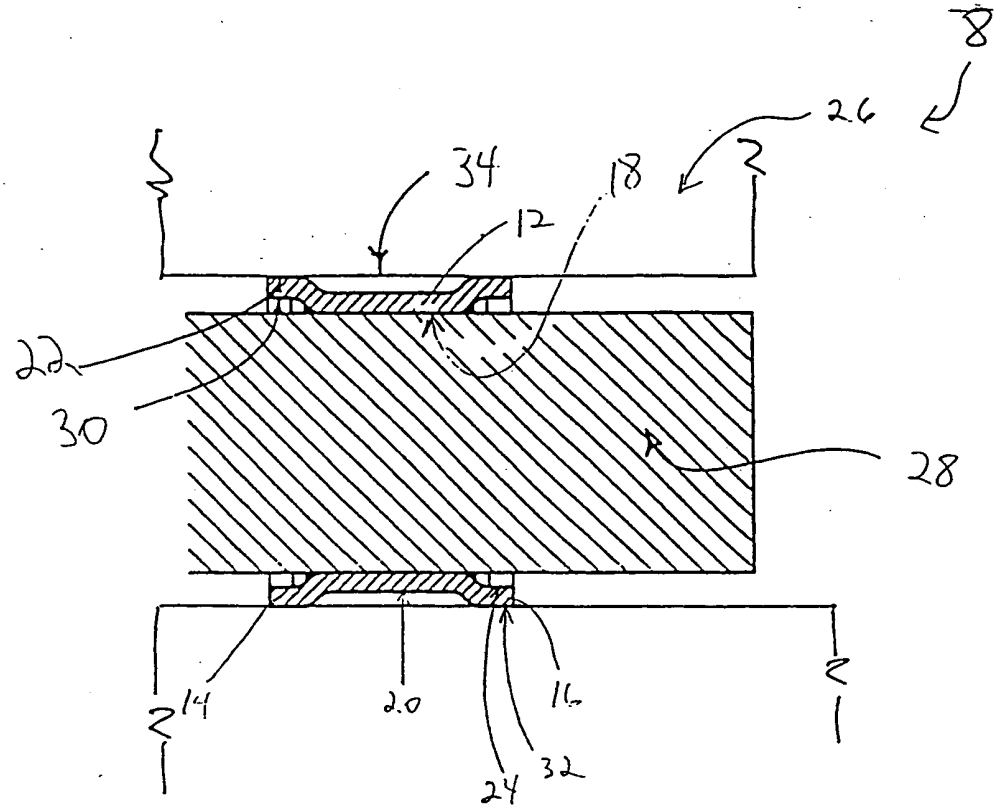

FIGURE 3

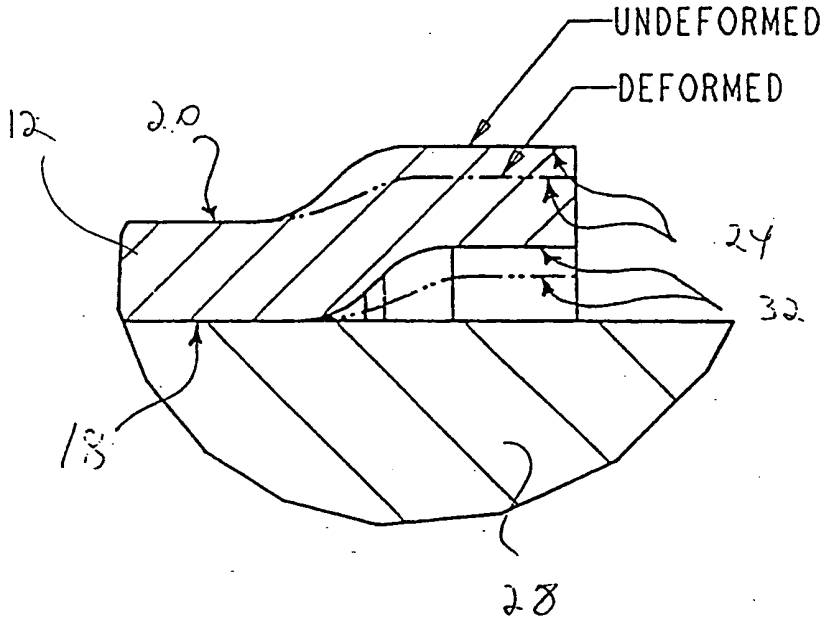

Figure 4

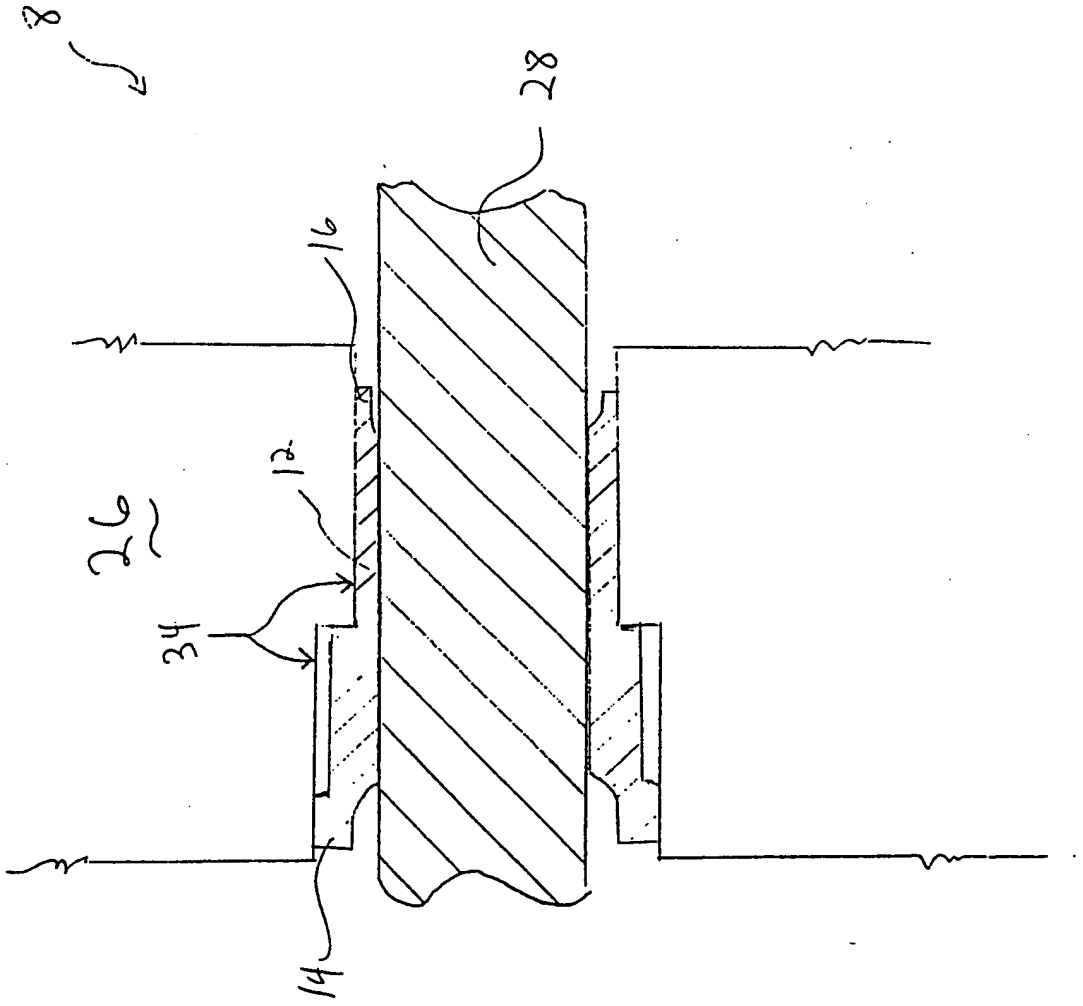

Figure 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/22089

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F16C33/20 F16C27/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F16C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 272 499 A (IBM) 29 June 1988 see the whole document	1-3,6, 8-10,13, 15
A	US 5 358 340 A (BOBER) 25 October 1994 see the whole document	1-3, 6-10, 13-15,18
A	DE 13 03 587 B (LANDIS) 9 March 1972 see the whole document	1,2
A	EP 0 558 850 A (IDE) 8 September 1993 see figures 4,5	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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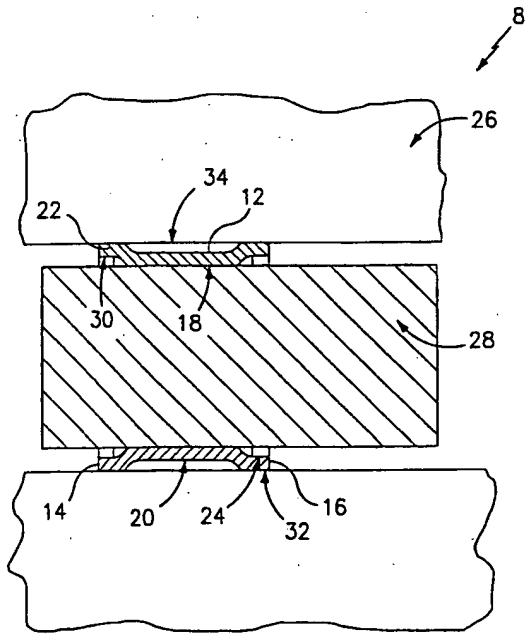

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Attempts have been made in the past to retain the bearing within the housing bore. Many techniques have been implemented at the cost of additional assembly steps or tooling costs. For example, Rosen, U.S. Patent No. 4,913,562 teaches a center flange arrangement wherein the flange engages the housing by an internal groove. The internal groove must be added to the housing often requiring

added expense due to machining costs. Further, the flange must be designed to properly fit within the bore and the groove engaging it. Further external flanges make it difficult to insert the bearing into the housing. Rosen U.S. Patent No. 4,913,562 addresses this difficulty by creating a diagonal slit longitudinally down the bearing. The bearing can now be flexed helically to install it into the housing bore. The slit must be incorporated into the molding process of the bearing creating additional tooling expense.

End flanges have been used to eliminate the need for creating an internal groove in the housing bore. Flem, U.S. Patent 5,145,265 teaches of such a technique, but also includes a longitudinal diagonal slit down the side wall of the bearing for ease of installation.

It is advantageous to have a bearing that can be molded using a simple technique, that is without slits or flanges. Further, it is desirable to provide a bearing that is easy to install, eliminating the need to create helical slits or cuts within the bearing. Additionally, a bearing that supports a shaft continuously without an interruption of a diagonal slit is preferred.

SUMMARY OF THE INVENTION

A plane bearing assembly includes a bearing defining a longitudinal axis and having an intermediate portion bounded on opposed longitudinal ends by first and second end portions. The intermediate portion has an inner working surface and an outer relief surface. The first and second end portions have an outer surface which extends radially outward from the outer relief surface of the intermediate portion such that the intermediate portion can be relieved relative to the first and second end portions without substantial deformation of the inner working surface.

BRIEF DESCRIPTION OF DRAWINGS

The invention will be described in detail in the following description of preferred embodiments with reference to the following figures wherein:

FIG. 1 is an isometric view of a preferred embodiment of an improved bearing assembly;

FIG. 2 is a cross-sectional view of a preferred embodiment of an improved bearing assembly;

FIG. 3 shows a cross section of the bearing assembly installed within a housing bore with a shaft passing through the bearing; and

FIG. 4 shows a magnified cross-sectional view of end portion 16.

FIG. 5 shows a cross-sectional view of housing structure 26 wherein interior surface 34 includes different diameters.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

An improved bearing assembly is cylindrically shaped with raised end portions. The raised end portions create an interference fit with the interior of a housing bore in which it is installed. The improved bearing provides a low friction, low wear surface for contacting a shaft within its internal bore. The internal bore provides a working surface that is continuous for consistent contact with a shaft during operation. Further the press-fit of the bearing minimizes close-in over the working interior bore of the bearing, that is the bearing's inside diameter does not impinge significantly on the clearance between the bearing and the shaft.

Referring to the figures, FIG. 1 is an isometric view of a preferred embodiment of a plane bearing 10.

FIG. 2 is a cross-sectional view of a preferred embodiment of bearing 10. The bearing assembly defines a bore 11. Bearing 10 is generally cylindrical in shape with two end portions 14 and 16. The bearing has an intermediate portion 12 which has an inner working surface 18 which supports a shaft 28 during operation. In a preferred embodiment, raised end portions 14 and 16 maintain a constant wall thickness which is approximately equal to the wall thickness of the intermediate portion 12. However, other thicknesses for end portions 14 and 16 are contemplated. Outer surfaces 22 and 24 of the end portions 14 and 16 are extended radially outward beyond the intermediate portion's outer relief surface 20. Also, a preferred embodiment includes inner surfaces 30 and 32 of end portions 14 and 16 which define a larger diameter than inner working surface 18 of intermediate portion 12 of bearing 10. Because end portions 14 and 16 are raised, outer relief surface 20 is defined in intermediate portion 12 of bearing 10. Slots 23 may also be formed in end portions 14 and 16. These slots 23 facilitate accommodation of bearing 10 in a carriage.

FIG. 3 shows a cross section of a bearing assembly 8 installed within a housing bore with a shaft passing through bearing 10. A housing structure 26 defines a bore having an interior surface 34. Bearing 10 is press-fit into housing structure 26. Outer surfaces 22 and 24 of end portions 14 and 16 contact interior surface 34 of housing structure 26. The diameter of housing structure 26 is less than the diameter defined by outer surfaces 22 and 24 of end portions 14 and 16. Therefore, an interference fit is created. Bearing 10 may be made of a compliant material which can deform at end portions 14 and 16 (See FIG. 4). Preferably, outer relief surface 20 of intermediate portion 12 does not contact interior surface 34 of housing structure 26. Inner working surface 18 is in contact with shaft 28,

however enough clearance is allocated for shaft 28 to translate, rotate or translate and rotate simultaneously.

Appropriate clearances between interior surface 34 and outer surfaces 22 and 24, as well as, between shaft 28 and inner working surface 18 are important to the proper operation of the configuration. Preferred interferences between interior surface 34 and outer surfaces 22 and 24 of end portions 14 and 16 are in the range of .001 to .005 inches for housing structure bore diameters of approximately .25 inches to 2.50 inches. Typical clearances between the diameter of shaft 28 and the diameter of inner working surface 12 are nominally .004 inches for shaft diameters between .25 inches to about 2.50 inches. Too much clearance is detrimental to the efficient operation of the bearing. Chatter or noise can result as well as rough motion of the shaft. Clearance that is too small can cause shaft interference which is also non-beneficial to bearing operation.

A preferred embodiment of this invention addresses these concerns. The diameter of outer surfaces 22 and 24 of end portions 14 and 16 is larger than interior surface 34 of housing structure 26. There exists a condition of interference between the two which is maintained within the preferable range of .001 to .005 inches for approximate housing bore diameters between .25 inches to about 2.5 inches. This range may increase as required by increasing shaft diameter. Outer relief surface 20 is smaller than the diameter of the housing bore. Therefore, there is no interference in the intermediate portion 12 of bearing 10, since shaft 28 is supported by the inner working surface 18 in intermediate portion 12. Preferably any reduction in diameter of inner working surface 12 is maintained below .003 inches to remain within the nominal clearance range of .001 to .004 inches for shafts less than .25 inches to about 2.5 inches.

FIG. 4 shows a magnified cross-sectional view of end portion 16. End portion 16 is shown in an undeformed structure (solid lines) and a deformed structure (dashed lines). The solid lines represent end portion 16 prior to press-fitting bearing 10 into bore 26. When bearing 10 is pressed into housing structure 26 both inner surface 32 and outer surfaces 24 deform radially inward, filling at least part of the available space between inner surface 32 and shaft 28. Since only outer surface 24 of end portion 16 is in contact with housing bore 26, intermediate portion 12 is not loaded externally, and therefore does not substantially deform radially inward closing in the diameter of inner working surface 12. Therefore, a press-fit bearing arrangement is realized maintaining an appropriate clearance between shaft 28 and the inner working surface 12.

Preferred material characteristics for bearing 10 include low-friction, low-wear, high strength and good performance at elevated temperatures. Materials with some flexibility are desired to undergo the deformation of press fitting without excessive stress. It is also desirable that the materials are resilient enough to hold their shape so that cold flow or creep does not present problems for the bearing. In preferred embodiments polymeric materials may be used in particular, polyamide (PA) including but not limited to nylon 6/6, polyphenylene sulfide (PPS) and polyphthalamide (PPA) thermoplastics.

Alternate embodiments of bearing 10 include end portions 14 and 16 having different diameters. FIG. 5 shows a cross-sectional view of housing structure 26 wherein interior surface 34 includes different diameters. It is also contemplated that end portions 14 and 16 can have different longitudinal lengths to accommodate varying housing structure sizes. It is further contemplated that intermediate portion 12 can have varied longitudinal lengths and diameters to accommodate varying housing structures.

Having described preferred embodiments of an improved bearing (which are intended to be illustrative and not limiting), it is noted that the modifications and variations could be made by those skilled in the art in light of the above teachings. It is therefore to be understood that changes may be made in the particular embodiments of the invention disclosed which are within the scope and spirit of the invention defined by the appended claims.

WHAT IS CLAIMED IS:

1. A plane bearing assembly comprising:

a bearing defining a longitudinal axis and having an intermediate portion bounded on opposed longitudinal ends by first and second end portions, the intermediate portion having an inner working surface and an outer relief surface, the first and second end portions having an outer surface which extends radially outward from the outer relief surface of the intermediate portion such that the intermediate portion can be relieved relative to the first and second end portions without substantial deformation of the inner working surface.

2. A plane bearing assembly as recited in claim 1 further comprising a housing structure defining a bore for receiving the bearing therein.

3. A plane bearing assembly as recited in claim 2 wherein the first and second end portions having an interference fit with the housing structure.

4. A plane bearing assembly as recited in claim 3 wherein the interference fit is between .001 and .005 inches.

5. A plane bearing assembly as recited in claim 2, wherein the inner working surface deforms less than or equal to .003 inches.

6. A plane bearing assembly as recited in claim 1 wherein the bearing consists of a polymeric material.

7. A plane bearing assembly as recited in claim 6 wherein the bearing consists of polyamide.

8. A plane bearing assembly comprising:

a substantially cylindrical bearing defining a longitudinal axis and having an intermediate portion bounded on opposed longitudinal ends by first and second end portions, the intermediate portion having an inner working surface and an outer relief surface, the first and second end portions having an outer surface which extends radially outward from the outer relief surface of the intermediate portion such that the intermediate portion can be relieved relative to the first and second end portions without substantial deformation of the inner working surface; and

the first and second end portions having an inner surface extending radially outward from the inner working surface allowing for radially inward deformation of the first and second end portions.

9. A plane bearing assembly as recited in claim 8 further comprising a housing structure defining a bore for receiving the bearing therein.

10. A plane bearing assembly as recited in claim 9 wherein the first and second end portions having an interference fit with the housing structure.

11. A plane bearing assembly as recited in claim 10 wherein the interference fit is between .001 and .005 inches.

12. A plane bearing assembly as recited in claim 8, wherein the inner working surface deforms less than or equal to .003 inches.

13. A plane bearing assembly as recited in claim 8 wherein the bearing consists of a polymeric material.

14. A plane bearing assembly as recited in claim 13 wherein the bearing consists of polyamide.

15. A plane bearing assembly comprising:

a polymeric substantially cylindrical bearing defining a longitudinal axis and having an intermediate portion bounded on opposed longitudinal ends by first and second end portions, the intermediate portion having an inner working surface and an outer relief surface, the first and second end portions having an outer surface which extends radially outward from the outer relief surface of the intermediate portion such that the intermediate portion can be relieved relative to the first and second end portions without substantial deformation of the inner working surface;

a housing structure defining a bore for receiving the bearing therein; and

the first and second end portions having an inner surface extending radially outward from the inner working surface allowing for radially inward deformation of the first and second end portions wherein the first and second end portions having an interference fit with the housing structure.

16. A plane bearing assembly as recited in claim 15 wherein the interference fit is between .001 and .005 inches.

17. A plane bearing assembly as recited in claim 15, wherein the inner working surface deforms less than or equal to .003 inches.

18. A plane bearing assembly as recited in claim 15 wherein the bearing consists of polyamide.

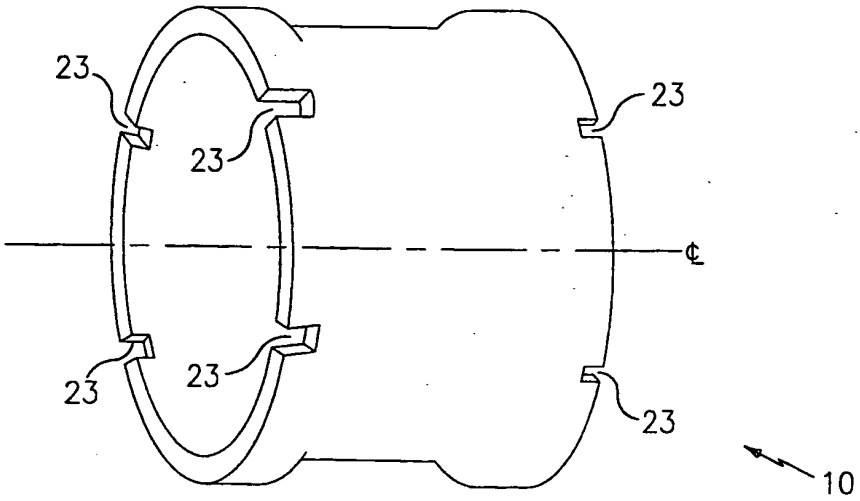

FIG. 1

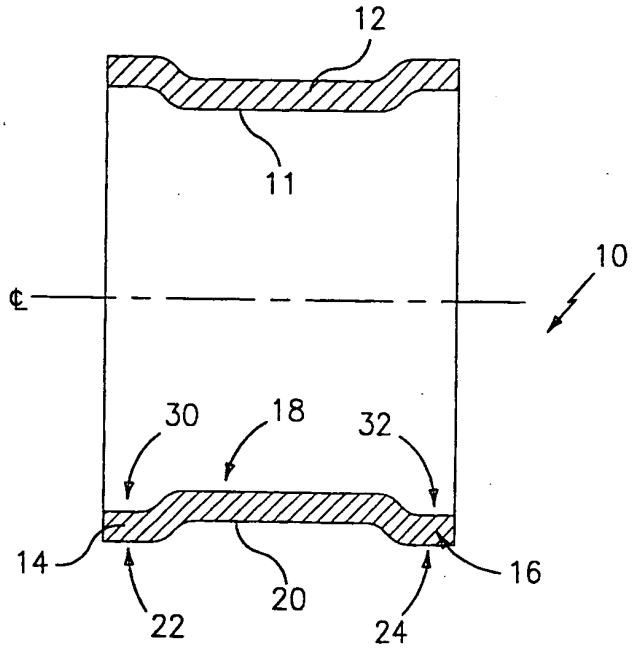

FIG. 2

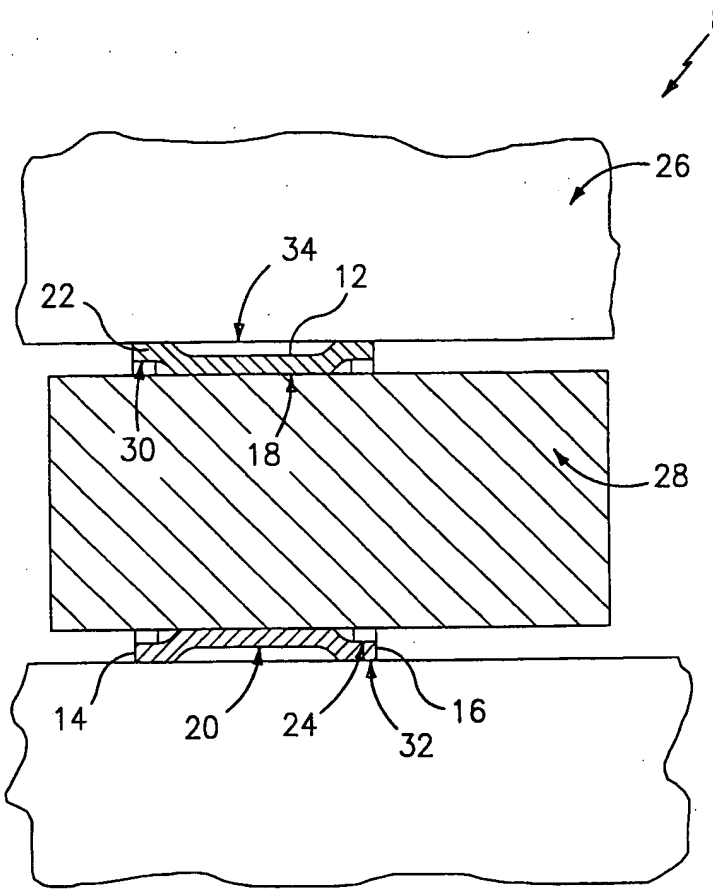

FIG. 3

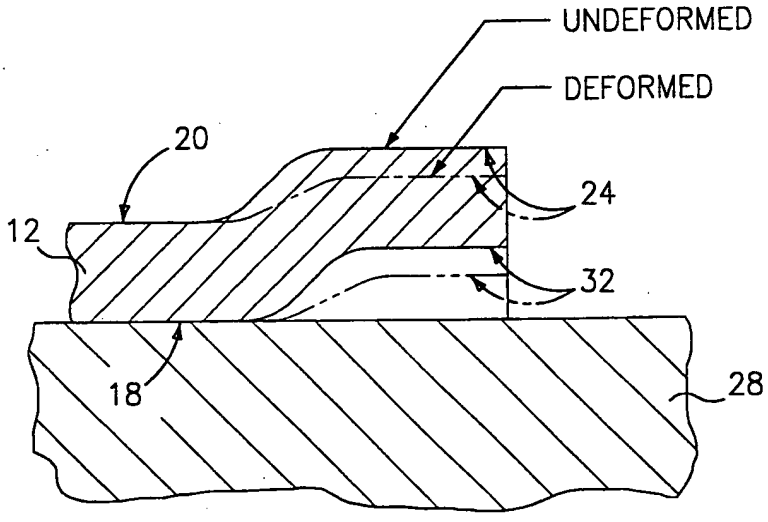

FIG. 4

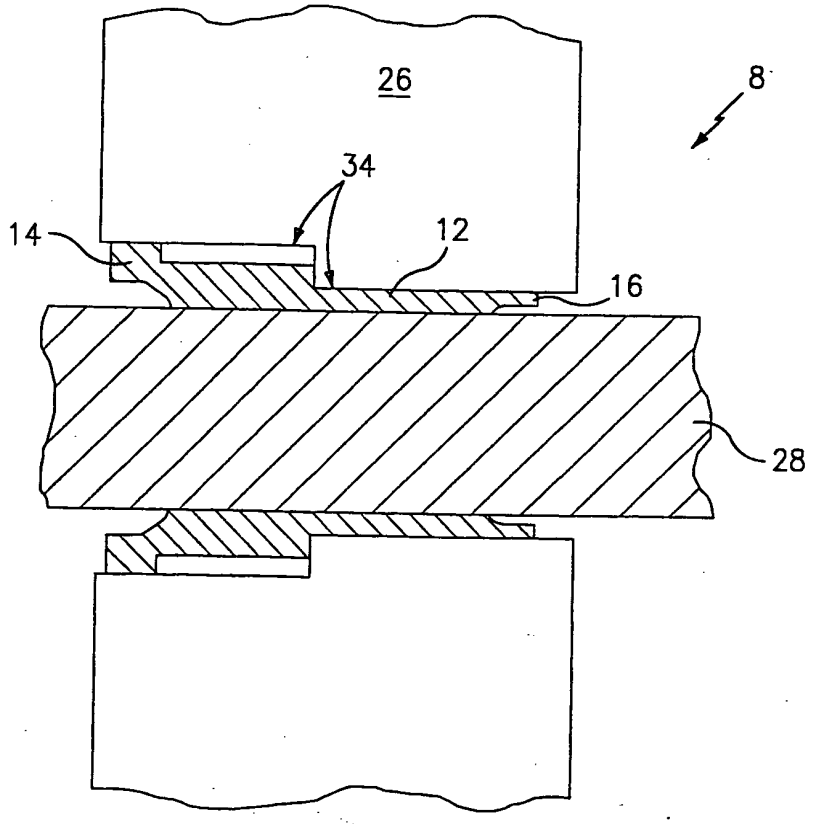

FIG. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/22089

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F16C33/20 F16C27/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F16C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 272 499 A (IBM) 29 June 1988 see the whole document	1-3,6, 8-10,13, 15
A	US 5 358 340 A (BOBER) 25 October 1994 see the whole document	1-3, 6-10, 13-15,18
A	DE 13 03 587 B (LANDIS) 9 March 1972 see the whole document	1,2
A	EP 0 558 850 A (IDE) 8 September 1993 see figures 4,5	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 January 1999	02/02/1999

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/US 98/22089

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